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Apparatus for pasteurizing red meat carcasses

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Apparatus for pasteurizing red meat carcasses

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SUMMARY

Three types of apparatus for pasteurizing red meat carcasses are commercially available. In the Stanfos and CHAD apparatus, the surfaces of carcasses are heated with recirculated hot water. Steam at above atmospheric pressure is used for heating carcass surfaces in the Frigoscandia system. The characteristics of each apparatus is identified, and their performances are compared in so far as the available scientific and commercial information allows.

RÉSUMÉ

Trois types d'appareils pour pasteuriser les carcasses de viande rouge sont présentement disponibles sur le marché. Les appareils Stanfos et CHAD chauffent la surface des carcasses à l'aide d'eau chaude recirculée. Les appareils Frigoscandia utilisent de la vapeur sous pression. Les caractéristiques et la performance de chaque appareil sont identifiées et comparées d'après l'information scientifique et commerciale disponible.

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Introduction Most red meat packing plants in North America are implementing Hazard Analysis: Critical Control Point (HACCP) systems to control the contamination of meat with pathogenic bacteria during carcass dressing. Unfortunately, many such systems are based on erroneous, subjective judgements of the microbiological hazards associated with individual dressing operations and are therefore ineffective for controlling hazardous contamination (Gill, 1998). However, even when a HACCP system is soundly based on appropriate microbiological data, contamination with pathogenic bacteria cannot be entirely prevented (Gill *et al.*, 1998a). A decontaminating treatment is therefore required for enhanced surity of an acceptable microbiological condition of carcasses leaving a dressing process.

Various physical and chemical treatments have been proposed for decontaminating dressed carcasses. Although many have been shown to be effective for reducing the numbers of bacteria on inoculated portions of meat under laboratory conditions (Dorsa *et al.* 1996; Hardin *et al.* 1995: Regan *et al.*, 1996), most are ineffective when used under commercial conditions (Gill and Bryant, 1997; Gill *et al.* 1996). Even when a treatment is effective, the reductions in numbers of the natural flora are far less than the reductions obtained with inoculated bacteria (Smith and Graham, 1978). Thus, reports in the literature of experimental decontaminating treatments are poor guides to the effects of treatments which are useful in commercial practice. However, from plant and pilot studies of the possible treatments, pasteurizing of the whole of the surfaces of carcasses or carcass sides has emerged as the one likely to be of most practical benefit in most circumstances (Gill and Bryant, 1997; Gill *et al.* 1997; Gill *et al.* 1998b; Nutsch *et al.* 1997). Consequently, apparatus for pasteurizing carcasses are now available from three suppliers. As many plant managements may wish to choose amongst those in the near future, an account of the information available on each would seem to useful to the meat packing industry.

Apparatus The manufacturers of the three types of apparatus are Stanfos Inc., Edmonton, AB, Canada; CHAD, Lenexa, KS, USA; and Frigoscandia, Bellevue, WA, USA. The information available on each from scientific and commercial publications and industry communications is summarized in Table 1. As the relevance and quality of the individual items of information are varied, a gloss on each line of information is provided.

TABLE 1. APPARATUS FOR PASTEURIZING CARCASSES

Summary of the characteristics of commercially available apparatus for pasteurizing red meat carcasses.

Characteristic	Equipment Type[1]		
	Stanfos	CHAD	Frigoscandia
Treatment Medium	Water	Water	Steam
Coverage	100%	Not identified	100%
Reliability	100%	100%	75 to 98%
Heating Medium	General Purpose Steam	General Purpose Steam	Culinary Steam
Treatment Medium Use	Recirculated	Recirculated	Vented
Pre-treatment Operation	Washing	Washing	Drying
Post-treatment Operation	None	Drying; Cold Wash; Acid Wash	Cold Wash
Complexity	Low	Moderate	High
Size (length x width):			
Beef:≤ 100 carcasses/h	1.7x1.5m	3.3x1.5m	Not identified
Beef: >200 carcasses/h	3.5x1.5m	5.5 x 1.5m	11.3 x 1.2m
Cleaning	Daily CIP	Daily CIP	Daily plus weekly
Treatment: temp. x time	83°C x 10s	74 to 82°C x 5 s	105°C x 6.5 s
Remaining Bacteria:			
Escherichia coli on beef	0.02%	Not identified	0.2%
Escherichia coli on pork	0.04%	Not identified	Not identified
Total aerobes on beef	0.7%	Not identified	8.8%
Total aerobes on pork	2.0%	Not identified	Not identified
Affect on Appearance	----------Discolouration of Cut Muscle Surfaces----------		
Cost of Equipment:			
Beef:≤ 100 carcasses/h	$ 100 k	$ 152 k	Not identified
Beef: >200 carcasses/h	$ 200 k	$ 300 k	$ 800 k
Cost of Installation	----------Variable----------		
Energy Use:			
Per beef carcass	Not identified	1.8 M joule	30 or 6 M joule
Per pig carcass	0.4M joule	Not identified	Not identified

[1] Stanfos Inc., 3908 69 Avenue, Edmonton, AB, Canada, T6B 2V2. Phone 403-468-2165, Fax 403-465-4890
CHAD, 11531 West 83rd Terrace, Lenexa, KS 66214, USA. Phone 913-894-0123; Fax: 913-894-0205
Frigoscandia, P.O. Box 3984, Bellevue, WA 98009, USA. Phone 206-883-2244; Fax: 206-882-0948

Treatment Medium. Carcass surfaces can be heated with hot water or steam. When hot water is used, a major consideration is prevention of the water cooling below a pasteurizing temperature before it reaches the carcass surface. Such cooling tends to occur with sprays, because the water droplettes in a spray present a large surface area for rapid evaporation and consequent cooling of the water. The problem is addressed in the Stanfos system by water being generated as sheets, which present only small surface areas. With that system the temperature difference between the outlet and the returning water is typically < 3°C.

In the CHAD system, water is projected as jets from spray heads with relatively large orifices, which are mounted on headers that oscillate, typically at 90 strokes/min. The oscillations break up the jets to give a large surface area for cooling. That matter is remedied by siting the nozzles close to the carcasses. None the less, a temperature difference of at least 8°C between the outlet temperature and the water temperature at some points on the carcass surface is indicated.

In the Frigoscandia system, the carcass surface is heated by the condensation of steam from a steam atmosphere. To obtain a uniform steam atmosphere, the steam is applied at above atmospheric pressure in a sealed chamber. That is in marked contrast to the open systems used for water pasteurization. To allow treatment in a sealed chamber on a high speed line, the treatment chamber is designed to move with a batch of carcasses while they are being treated.

Coverage. The sheets of water generated in the Stanfos system can be directed as required. In apparatus for continuous throughput of carcasses, the water sheets are generated from above and below the carcass across the width of the apparatus. As a carcass pushes through each sheet, the sheet tends to maintain coherence and deforms around the carcass surface. In an apparatus where each carcass or carcass side comes to rest for treatment, the sheets are generated to strike the carcass in a pattern which gives flows of water over all surfaces, as determined by experimentation. In either case there is assurance of complete coverage of all surfaces of the carcass.

The CHAD system is adapted from that company's established carcass washing system. Coverage of much of the carcass can than be expected. However, coverage does not appear to have been examined experimentally, so it is possible that some areas of carcasses receive inadequate or no water. As water is delivered from the sides the system would, for example, be inadequate for treating the body cavity surfaces of unsplit pig or sheep carcasses or paired pig carcass sides.

In the Frigoscandia system, the condensation of steam from a uniform steam atmosphere gives rapid, uniform heating of all carcass surfaces irrespective of the surface geometry.

Reliability. With both of the systems which use water, a treatment will be applied provided the apparatus is operating to dispense hot water. However, with the Frigoscandia system, an effective treatment will be applied only if the treatment chamber is sealed. In practice, chamber sealing has proved to be a problem because of portions of a carcass blocking either the entrance or exit door of the chamber. Operators of the system estimated that such blockage reduced the reliability of the treatment to about 75%. To overcome that, some operators have modified the equipment to accumulate batches of carcasses at a stop on the rail before the treatment chamber, which is kept stationary. Each batch is then moved into and stops within the chamber for treatment. Obviously, a dedicated drive chain is required for moving batches in and out of the treatment chamber. By that means, the reliability of the treatment has been raised to an estimated 98%.

Heating Medium. All three systems use steam for heating. The Stanfos system heats water with low or high pressure steam, as is available at each plant for general use. The water is heated to the required outlet temperature in a shell and tube heat exchanger as it passes to the headers for distribution over carcasses.

In the CHAD system, water in a storage tank is heated, apparently by a heat exchanger. However, the CHAD literature mentions heating by steam injection, which might imply the use in some apparatus of heating by direct steam injection. The capital costs for direct injection are usually less than heating by a heat exchanger, but if direct injection is used the steam should be of culinary quality. That is, it must be generated in a boiler system which is constructed of food compatable materials and in which only food compatible boiler chemicals are used.

The steam used for direct heating of carcasses in the Frigoscandia system should, of course, be of culinary quality.

Treating Medium Use. In both the Stanfos and the CHAD systems, water is delivered at rates of up to 1000 l/min. Such use of hot water obviously requires that the water be recirculated, to contain operating costs. It has been shown in the Stanfos system that few if any bacteria survive in the circulating water. Presumably the same is true for the CHAD system, as water in that and the Stanfos system are similar heated to >82°C. Some water is lost during the operation of both systems. The available figures are, for treatment of uneviserated pig carcasses with the Stanfos system 0.5 l/carcass; and for treatment of beef carcass sides with the CHAD system 13 l/carcass. That suggests that, for equivalent

circumstances, water losses may be greater from the CHAD than from the Stanfos system.

As water is recircualted in both systems, debris, hair and denatured protein will accumulate in the water. The water in both is passed through coarse filter screens when being drawn into the pump. With the Stanfos system, that is done simply to facilitate cleaning, as the water is projected from orifices of 19 mm diameter which are too large to be blocked by any detritus from washed carcasses. In contrast, water in the CHAD system is projected from orifices of 3 mm diameter, which are small enough to be blocked by detritus in recirculated water.

The steam used for treating carcasses in the Frigoscandia system is vented. For treatment of beef carcasses, the water used for stream generation is given variously as 11 l/carcass for equipment operating on a high speed line, or 2 l/carcass for equipment suited for use at small plants.

Pre-Treatment Operations. The Stanfos and CHAD systems both wash as well as heat the surfaces of carcasses. However, washing before treatment in the Stanfos system is desirable to remove much blood and bone dust, which would otherwise degrade the quality of the circulating water. Washing before the treatment in the CHAD system is probably necessary to minimize blocking of water jet orifices as well as to avoid excessive degradation of the circulating water quality. There is no washing action in the Frigoscandia system, so any detritus on a carcass will remain in the same position throughout the treatment. The steam will heat only surfaces, so for any detritus, the detritus rather than the meat surface it covers will be heated. Any surface covered by detritus will therefore be protected from the pasteurizing treatment. Consequently, the carcass surface must be wholly freed from detritus before it is treated with steam. Moreover, the surface must be dry. Otherwise the steam will merely raise the temperature of the film of water on the surface without raising the meat surface, and adhering bacteria, to pasteurizing temperatures.

Thus, with the Stanfos and CHAD systems, the pasteurizing treatment immediately follows carcass washing, but in the Frigoscandia system the washed carcasses are dried in a stream of high-speed air before they are pasteurized.

Post-Treatment Operations. With the Stanfos system, the heated carcass surfaces dry and cool rapidly by evaporation once the carcass has left the treatment chamber or the treatment is stopped. Thus, as there must be a flow of air into the equipment to make up for steam venting, there is usually no need for any further operation on carcasses between their leaving the pasteurizer and entering a chiller or hot carcass breaking process.

Carcasses from the CHAD system might be expected to behave similarly. Despite that, the cabinette is extended beyond the treatment chamber and fitted with fans to assure drying of the treated carcasses. In addition, the manufacturer suggests that in some circumstances a cold wash after pasteurizing may be necessary to ensure that carcasses are adequately cooled before entering a chiller. The manufacturer also recommends that the treated carcasses be subjected to an acid wash with a solution of lactic and/or acetic acid at a concentration of "up to 2.5%".

Despite various statements that CHAD acid wash systems are currently installed at 40 or 60 plants, acid washing of carcasses cannot be recommended. There are no published data on their efficacy in routine commercial use. Certainly, various experimental data have been published, but it is well established that large reductions under experimental conditions in the numbers of bacteria artificially inoculated onto meat do not reflect the reductions of the natural flora on commercial product by equivalent treatments. Moreover, it is difficult to apply a chemical solution to give uniform coverage of carcasses without excessive waste of solution, and enteric organism such as *E. coli* and *Salmonella* are known to be relatively insensitive to organic acid.

Apart from the dubious efficacy of organic acid washes for reducing the numbers of pathogenic bacteria, it should be recognized that the acids used are strong and corrosive. Thus, unless a plant is constructed of acid resistant materials, damage to concrete and metal other than stainless steel in the vicinity of acid spray equipment must be expected. With the Frigoscandia system, a cold water wash is applied after the pasteurizing treatment. Presumably, that is needed to cool the surfaces because of limited evaporation from surfaces that are essentially dry.

Complexity. The Stanfos water distribution system has only two moving parts, the pump and a valve system for bypassing the headers when carcasses are not being treated during any break in processing. The other moving parts are a dedicated chain to drive carcasses through the treatment chamber at a constant rate irrespective of the operation of the processing line or, with apparatus for the treatment of stationary carcasses, automatic door opening and closing mechanisms. The CHAD system appears to be little more complicated, except for the oscillating headers which are a component tested by long use in carcass washing systems.

The Frigoscandia apparatus is more complicated because of the sealing and moving treatment chamber. Some simplification is achieved if movement of the chamber is abandoned for movement of batches into and out of a stationary chamber.

Size. The cabinettes for the Stanfos and CHAD systems are somewhat wider than those for the Frigoscandia system because the former must accommodate headers for water distribution which are not required in the Frigoscandia system. Although the treatment time in the CHAD system is less than that in the Stanfos system, the CHAD cabinette is longer for comparable throughputs of comparable carcasses, apparently because of an extension of the cabinette for carcass drying by a stream of air. The provision of air curtains to contain steam in the CHAD but not the Stanfos system would also increase the length of the CHAD cabinettes. Addition of an acid spray treatment chamber to the CHAD pasteurizing chamber increases the length of any unit by about 1m.

The cabinette for the Frigoscandia system which employs a treatment chamber that moves along the dressing rail is necessary considerably longer than the water treatment cabinettes, to accommodate the chamber movement. The length required might be somewhat reduced if the equipment is modified to treat carcasses in a stationary chamber. However, additional line space would then be required for the accumulation of each batch before it is moved into the treatment chamber. For small rates of carcass throughput the treatment cabinette apparently moves vertically instead of horizontally, and so occupies a relatively short length of the processing line.

Cleaning. The Stanfos equipment is constructed for cleaning in place (CIP) to dairy industry standards. The CHAD equipment is also designed for cleaning in place. Both types of equipment are cleaned daily by draining, foaming and manual scrubbing of internal walls, and circulation of first an alkaline detergent solution then rinsing water. The internal walls of the Frigoscandia equipment are similarly cleaned each day, but the treatment chamber must apparently be dismantled each week for cleaning and maintenance.

Treatment Temperatures and Times. To identify a pasteurizing treatment both a treatment temperature and a treatment time must be specified. Early studies of meat pasteurizing established that the maximum destruction of bacteria with hot water is obtained with a treatment of >80°C for 10s. Increasing the treatment temperature or time within practical limits beyond those does not produce any substantial decrease in the numbers of bacteria of the natural flora which survive. However, decreasing the treatment temperature below 80°C or the treatment time below 10s can substantially increase the numbers of survivors.

The Stanfos system is designed and is in practice operated to raise carcass surface

temperatures uniformly to between 83 and 85°C for 10s. Thus, the maximum practical destruction of bacteria by pasteurizing is obtained with the Stanfos system. In contrast, the CHAD system is apparently designed to raise carcass surface temperatures to between 74 and 82°C for 5s. That is, to give substantially less than the maximal destruction of bacteria.

Data on the pasteurizing of carcasses with steam equivalent to those data on pasteurizing carcasses with hot water are not available. However, because the treatment temperature must be above that of water boiling at atmospheric pressure, the maximal effect might be expected with a treatment time less than that with water. A shortened treatment time is desirable to minimize damage to the appearances of treated carcasses. Thus, in practice, the Frigoscandia system is operated to heat the surfaces of carcasses to 105°C for 6.5 s.

Remaining bacteria. Bacteria vary widely in their susceptibility to destruction by heating. Of the bacteria commonly found on newly dressed carcasses, Gram-negative organisms such as *E. coli*, the pathogen *Salmonella* or the pseudomonads, which are potent spoilage organisms, are more susceptible to pasteurizing treatments than are Gram-positive bacilli and micrococci which play no part in either disease or spoilage. Consequently, if numbers of *E. coli* and of total aerobic counts before and after a pasteurizing treatment are determined, a greater reduction in the numbers of *E. coli* than of the total aerobes can be expected. The remaining microflora will be enriched for the thermoduric, Gram positive species.

The effects of treatment in the Stanfos system on the bacteria on commercial pig and beef carcasses have been examined. The results indicate that the total aerobes are reduced by about 99% while *E. coli* are reduced by >99.9%. The effects of the CHAD system on the microbiological condition of commercial carcasses has not been reported. The Frigoscandia system is used with beef carcasses on which it reduces total aerobes by about 90% and *E. coli* by >99%. Thus, when operated as at present, the Frigoscandia system appears to be less effective than the Stanfos system. The effects of the CHAD system have yet to be determined, but the stated treatment temperatures and times suggest that it may well be less effective than the other systems.

Affect on Appearance. The heating of meat must be expected to produce some changes in its appearance. Those changes have been formally investigated for pasteurizing treatments with hot water.

Studies with pieces of meat dipped into hot water showed that with a treatment temperature of 85°C

TABLE 2. EFFECTS OF PASTEURIZING ON CARCASSES APPEARENCE

Differences between mean scores for the overall appearances of carcasses or sides which had not been treated or had been pasteurized using Stanfos equipment.

Treated Unit	Assessed Unit	Differences of Means (untreated-treated)
Beef Carcass Side	Side	0.41
Pig Carcass Side	Side	1.92
Unsplit Pig Carcass	Side	-0.29
Sheep Carcass	Carcass	0.27

Sides and carcasses were assessed on a 7-point scale where 1=very undesirable, 4=neither desirable nor undesirable, and 7=very desirable.

treatment times of up to 20 s had relatively little effect upon the appearances of fat, cut bone or membrane covered surfaces, but that cut muscle surfaces were dulled, darkened and browned, or bleached. The appearances of cut beef muscles treated pre-rigor tended to improve after the development of rigor, but those of cut pork muscles did not. Further, the appearance of pig muscle of pale, soft, exudative (PSE) quality was degraded to a greater extent than muscle of dark, firm, dry (DFD) quality. Those findings suggested that pasteurizing of beef carcasses sides would degrade the appearances of some, but not to the extent of rendering their appearances unacceptable. Pig carcass sides were likely to appear far less acceptable after treatment unless pig carcasses were treated before rather than after they were split.

Those deductions were confirmed by treatment and assessment of commercial carcasses (Table 2). In general, when sides of beef were treated in the Stanfos system and compared with untreated sides from the same carcasses, the appearances of about half of the treated sides were judged by a panel to be less desirable than the equivalent untreated sides, because of discoloration of cut muscle surfaces. However, the differences between treated and untreated sides were no more than one unit on a 7-point assessment scale, and all the treated sides were judged to be fully acceptable for commercial purposes. Findings for treated as compared with untreated sheep carcasses were similar.

Treated sides of pig carcasses were assessed as up to 3 units less desirable than the equivalent untreated sides, but there was little difference between sides from carcasses which were treated before they were split and sides from carcasses which were not treated. As it is known that pig carcasses can be split without increasing bacterial contamination, treatment of pig carcasses before they are split is a

commercially viable treatment when carcass appearance is important. The effect on is unimportant if the carcasses are to be used for manufacturing comminuted meat products, as the cut muscle is affected to a depth of only 2 or 3 mm, so the affected tissue is not apparent in a mass of ground meat.

There are no similar data on the effects of pasteurizing with steam, but commercial, steam-treated beef sides show the same discoloration of cut muscle surfaces that is apparent on water-treated sides.

Thus, any microbiologically effective pasteurizing treatment must be expected to discolor cut muscle surfaces, but the treatment can be applied appropriately to avoid any financial loss from a treatment.

Cost of Apparatus. The prices given in the table are in $ Canadian. Quoted prices are available for Stanfos and CHAD apparatus. As might be expected from the greater complexity of the CHAD apparatus, the CHAD apparatus appear to cost about 50% more than equivalent Stanfos apparatus. Addition of an acid wash to the CHAD system increase the cost of any unit by about $ 30,000.

No prices are available for the Frigoscandia system. However, there have been personal communications to the effect that a unit for a high speed beef processing line would cost in excess of $800,000. To offset that, Frigoscandia can offer leasing arrangements which are not available for the other types of apparatus

Cost of Installation. The cost of installation will vary greatly for any type of apparatus with the modifications required to insert the equipment in or after the dressing line and provide electrical power, water, steam, drainage and venting for equipment. However, Stanfos or CHAD equipment will in most circumstances likely be less expensive to install than the larger and more complex Frigoscandia equipment.

Energy Use. Much of the cost for operating pasteurizing apparatus is the cost of energy for heating the treatment medium. For the Stanfos and CHAD systems, energy must be expended to raise the temperature of tank water and make up water above 80°C and to reheat the water returning from the carcasses. As there is apparently larger need for make up water and a larger difference between the outlet and return temperatures of water in the CHAD than in the Stanfos system, energy use is likely to be less in the Stanfos than in the CHAD system for equivalent throughputs of carcasses.

In the Frigoscandia system, energy costs arise largely from the generation of treatment steam. With the given requirements for make up water for operation of Frigoscandia apparatus it appears that energy use for large units will be 10 to 20 times greater for Frigoscandia than for CHAD or Stanfos

apparatus. For small units, energy use by the Frigoscandia equipment may be only 3 to 5 times greater than for equivalent CHAD or Stanfos apparatus.

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